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AUTHOR Sandalov, Aleksandr N.; Sukhareva, Natalia A.; Barry, Maurice; Piper, Terry; Stevens, Ken

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ABSTRACT

Two models for using information and communication technologies to teach physics to students in remote areas of Canada and Russia are described. In Canada, an intranet electronically links schools in a Newfoundland school district to the Memorial University of Newfoundland. Advanced placement physics is delivered via the Internet. Newfoundland has a high satellite dish rate per capita in a relatively small area, so synchronous, real-time networking is a high priority. In Russia, open distributed learning has been developed between Moscow State University and schools in Russia and other countries of the former Soviet Union. The ultimate aim is to provide access to universities and other academic institutions for more people throughout these countries through the development of a network "teaching auditorium." Russian time-zone differences of up to 9 hours plus unpredictable channel capacity make asynchronous information transfer very important. Educators in both countries have become aware that teachers and students must have compatible hardware and software for online teaching to be effective. The introduction of Internet-delivered physics raised issues of change in teaching and learning, including reduction of professional privacy for teachers; shift in the educational hierarchy with the advent of a new category of teacher; need for appropriate teacher education; keeping students focused in an unsupervised class; preventing students from becoming overwhelmed by access to unlimited information; and synchronizing scheduling at all locations. (TD)

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Aleksandr N. Sandalov
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Abstract

Russia and Canada are the two largest countries in the world in terms of geography and in each society, new information and communication technologies are being used to enhance the education of students in dispersed locations. This paper outlines two models for teaching physics from universities to students located in communities that are remote from major centres of population. The first model is being developed in Eastern Canada in which physics students are educated within a digital intranet, the sites of which are all located in rural communities in the province of Newfoundland and Labrador. The second model is Russian in which open distributed learning has been developed between Moscow State University and schools in both Russia and countries of the former Soviet Union. The paper concludes with an examination of the two models and a look at their future development in each country.

Authors:

Aleksandr N. Sandalov is an Associate Professor and Director of the Information Systems and Technology Centre of the Department of Physics, Moscow State University, Russia
Email: sandalov@phys.msu.su

Natalia A.Sukhareva is an Associate Professor and Vice-Dean of the Department of Physics at Moscow State University, Russia
Email: suhareva@phys.msu.su

Maurice Barry is a TeleTeacher of Physics in the TeleLearning and Rural Education Centre, Faculty of Education, Memorial University of Newfoundland, Canada
Email: mbarry@stemnet.nf.ca

Terry Piper is Dean of the Faculty of Education at Memorial University of Newfoundland (until October 1999), then Dean of Education at York University, Toronto, Canada
Email: tpiper@mun.ca

Ken Stevens is Professor of Education and Chair of the TeleLearning and Rural Education Centre, Faculty of Education, Memorial University of Newfoundland, Canada
Email: stevensk@mun.ca

The Development of Open Models for Teaching Physics to Schools in Dispersed Locations in Russia and Canada

Open classes for students in dispersed locations have become a feature of education in several parts of the developed world this decade. In Iceland (Stefansdottir, 1993), New Zealand (Stevens, 1995a, 1995b) and Finland (Tella, 1995) open classes provide access to an increasing range of learning opportunities for students who live in small and often remote communities. In all parts of the developed world in

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which information and communication technologies are being applied to the development of new, electronic educational structures, there is a search for appropriate ways of organizing teaching and learning (Goodyear,1999; Kynaslahti and Wager, 1999).

Russia and Canada are the largest and second-largest countries in the world respectively. Both Canada (Industry Canada, 1995;1997) and Russia increasingly depend on advancing, applying and integrating science and technology for the development of their knowledge-based economies and both societies contain significant regions that are remote from major centres of population. Russian and Canadian students who live beyond major urban areas increasingly depend on the application of information and communication technologies (ICT) for the delivery of educational opportunities.

Physics is a key domain of science, engineering and technology. Without access to instruction in Physics, students face reduced access to jobs in many scientific and technological fields. In the past it has been particularly difficult to attract, retain or even justify the appointment of specialist teachers of science in schools in rural communities in which student numbers have been small and access to scientific equipment has been difficult. Accordingly, many rural students have not, in the past, had equal access to scientific and technological occupations unless they completed their education in schools in larger centres.

Advances in ICT and in the electronic networking of schools have improved access to science in remote parts of Russia and Canada. This paper outlines the development of open models for teaching and learning physics in both countries, based on the integration of new information and communication technologies to pedagogy.

One: The Canadian Model - The Teaching of Advanced Placement Physics

In both the United States and Canada Advanced Placement courses are a well-established part of the senior High School curriculum for students who are able to undertake first-year University study. Depending on the level of pass obtained in the final examination, students can, through undertaking AP courses, gain credit towards their degrees before enrolling at a University.

In the Canadian province of Newfoundland and Labrador most schools (66%) are classified as rural. In district No. 8, the Vista School District, in which most schools are in small, rural communities, an Intranet was developed to electronically link eight sites. An integral part of the Vista Digital Intranet was the Centre for TeleLearning and Rural Education, located in the Faculty of Education of Memorial University of Newfoundland in the provincial capital, St Johns. The appointment of a teleteacher in the Centre for TeleLearning and Rural Education to teach Advanced Placement (AP) Physics students in three sites (schools) in the Vista Intranet provided both technological and pedagogical challenges.

The development of an AP Physics course for delivery through the Internet was undertaken over a sixteen-week period during the spring and summer of 1998. The teacher of Physics was assisted by a recent graduate in this discipline who had advanced computing skills in web page design, Java and HTML. Most of the AP Physics course development was through interaction between the lead teacher and the recent graduate, with reference, as appropriate, to professors in Science Education and Physics. This model facilitated interaction between the school system, graduate students and the Faculties of Education and Science of Memorial University of Newfoundland.

The introduction of Internet-delivered AP Physics in the Vista School District Digital Intranet represented two dimensions of change: (a) curriculum and technology and (b) the re-organization of classes within an Intranet.

(a) Curriculum and Technology

Several issues had to be considered in the development of the AP course:

1. *What hardware and software resources would be required to deliver instruction of an AP course to high school students in rural schools?*

Minimum specifications were adopted for computer hardware and network connectivity. All schools involved in the project had satellite dishes installed. Software had to be identified and evaluated. Software was required for both the development of the resources, and the delivery of instruction.

Software for development of the AP resources:

Front Page 98 was selected as the software package. Additional software was used for development of images, animated gifs, etc. These included Snagit32, Gif Construction Set, Real Video, and similar packages.

Software for student management and delivery of instruction:

Many software packages were evaluated and finallyWebCT was selected. This package enabled the instructor to track student progress, it contained online testing and evaluation, private email, a calendar feature, public bulletin board for use by both instructor and student, a link to lessons, chat rooms for communication between teacher and student, and more.

For real time instruction Meeting Point and Microsoft NetMeeting were selected. This combination of software enabled a teacher to present real-time interactive instruction to multiple sites.

2. *Students require training in the use of the hardware and software.*

An orientation session was provided to students in June of the year prior to implementation. Visits by instructors to students were carried out where required. Students has to learn how to communicate with each other and with their instructor using the Internet.

(b) The Re-organization of Classes In an Intranet

1. *Problems associated with the delivery of the lab component for the course.*

Problems of supervision and safety have had to be considered. This remains an issue that has not been finally resolved. The use of online video files and CD-ROMs are being explored.

2. *The nature of the high school students taking the AP course.*

The question how students would work in a completely independent learning environment has been prominent in the minds of researchers from the outset of each AP course. There is no teacher present on site and students are not normally used to being alone and largely unsupervised.

3. *Synchronous and Asynchronous Teaching and Learning- Establishing a common schedule (time-table) in all schools within the district.*

It was recognized early that a common schedule must be adopted throughout the district to allow students to be able to interact with their instructors. The initial plan was to allow for 5 online sessions and 5 offline sessions. This schedule was not followed in all schools. Online sessions are scheduled in the morning when network traffic is at its lowest point. Off line sessions are scheduled in the afternoon. Some schools chose not to be coordinated with the AP schedule for various valid reasons. As a result the instructor might be teaching another subject when the AP student would be in class. Students in different schools therefore have differing access to their AP Instructors. It is anticipated that in future there will be both asynchronous as well as synchronous teaching and learning within the Intranet, but at the present time it is not possible to provide other than synchronous access.

4. *The problem of student evaluation.*

The delivery of evaluation instruments is still being considered, but the researchers' preference is for electronic delivery. Both traditional paper/pencil and online testing are being evaluated. Student

preference at present is for paper/pencil type tests.

Two: The Russian Model

In the Russian education system OD courses are academic resources that are open to public discussion. On the one hand, academic processes may appear to be homogenous, with high standards of content. But, on the other hand, the principally asynchronous regime of educational communications in Russia and NIS make this type of delivery very vulnerable to subjective factors. It is possible to provide support for all "standard procedure" learning processes today through networked education. Networked education includes lectures with audio- video conference support, student classes with interactive tests, laboratory classes with on- line experimental facilities and electronic libraries with context-search systems and advisory board network services.

There is an emerging view that it is possible to mirror elementary and higher education through networked teaching and learning, based, in large part, on changing concepts of "information support." Information support includes not simply shaping the databases of academic courses and multimedia network developments, but through interactive on-line discussions and conferences with global research experimental facilities. Networked teaching and learning provides new and enhanced dimensions of student-teacher interaction and provides a basis for the development of virtual classes.

The changing basis of student - teacher interaction that is encouraged by the creation of new information support systems provides new ways of organizing learning:

1. From personal computers in student's homes;
2. From training auditoriums;
3. From teachers at schools and teachers in universities.

New developments in teacher-student interaction have to take into consideration changes in the direction of global telecommunications systems.

1. The increasing a number of users with mainly low velocities of access (modem connection from 9.600 before 56.400 kb/s);
2. Developing high speed performance links, uniting academic server clusters in the global academic information structure;

The relative simplicity of standard Web applications encourages the conversion of text and multimedia files by students, providing them with enormous amounts of information from a "swollen" network database. This situation is providing difficulties for students who are increasingly required to distinguish between valuable and less-valuable information. A danger is emerging in this situation of a "cold-information cultural layer" as part of educational networking. The problem is that there is, for some students, too much "overflow" or too high a "noise level" in the amount of information that they can access and process. Educators using networked education systems have to keep in mind that it is important to pursue defined learning goals. Students can be overwhelmed by access to unlimited information.

The unity of the research and education activities inherent in university education has to be reflected in the development of information processing materials and electronic education books and other multimedia developments. It is possible to determine five directions for information support for students as they engage in new, networked educational processes:

1. The formation of information as a "mirror" of the auditorium work of the teacher;
2. The development of accompanying information materials to support the teacher's work;
3. The creation of on-line education "training machines" (local or global experimental facilities);
4. The development of On-Line and Out-Line assistance systems and knowledge testing;
5. The development of unified databases of education materials.

After three years testing information presentation, the following were selected as standards by the

Moscow State University network:

1. RealMedia - for direct access presentation to lectures in various disciplines,
2. RealMedia and MPEG3 - for audio accompanying system for foreign language teaching (English, German, French for Russian students and Russian for foreign students),
3. MPEG1 - for video accompaniment of different education courses,
4. JAVA - terminals for work with remote-access experimental systems,
5. PERL - management for interactive testing and assistance,
6. POSTGRESQL - Database as an integrated base of education developments at Moscow State University and other academic institutions in Russia.

These selections were based on the criteria of compatibility, speed and information security with different types of hardware and software in various regions of Russia with Moscow State University. Important considerations in the selection of formats for hypermedia resources include multi-platform compatibility, free access to program resources and the possibility of the installation of full server support on small PCs with standard configurations.

The Future Development of Each Model

The future development of the open models for teaching Physics in Russia and Canada will depend on developments in ICT and the extent to which these can be integrated with appropriate pedagogy. To continue to be effective, open models for teaching Physics to dispersed locations will have to be constantly evaluated.

(a) The Canadian Model

The Vista School District Digital Intranet is a prototype for the other ten school districts in the province and for the development of courses in other areas of the curriculum. There are a number of problems to be resolved during the first year and the prototype is being monitored regularly.

The move to an open environment in the teaching and learning of Physics is based upon a transition from an analog to a digital environment. Newfoundland and Labrador has a high rate of use of satellite dishes per capita and there are many schools in this province with LANs. As a province Newfoundland and Labrador provides excellent opportunities for the development of these technologies.

There are a number of teaching and learning issues that have been noted by observers of the Vista Digital Intranet:

Teaching Issues:

1. Teachers' work in Internet-based courses is open to the scrutiny of other members of the profession on the Internet. There is less professional privacy for teachers working in this open, inter-institutional model than they are used to in traditional classrooms.

2. Teachers of Internet-based AP courses are likely to gain increased prominence in their profession in Newfoundland and Labrador, assuming the role of expert practitioner. Will this lead to the emergence of a new category of "lead teacher?"

3. It has been observed that telelearning is the future of distance education (Collis, 1996). Future teacher education programs are likely to have to accommodate open, electronic teaching and learning.

Learning Issues:

1. AP Physics students in the Vista Digital Intranet faced problems adjusting to the difficulty of the subject matter and to a new mode of delivery. The implications of this experience for the development of other, less academically-advanced courses for average students, have to be

considered.

2. To what extent can the Internet be used in the teaching of Physics in conventional (face to face) classes?

(b) The Russian Model:

The creation of the Open Distributed Learning (ODL) system for the Universities and Schools of Russia has resulted in four developments:

1. The development an Inter-institutional network of communications to link all education services;
2. The convergence of educational material selection and presentation procedures;
3. The establishment of standards of network presentation using "multi-platform software applications";
4. The development of standards for hardware and software support in the networking of universities and other academic institutions.

The priority task in the development of educational networking in Russia has been the provision of information support within the educational process. To achieve this aim it has been necessary to find technological solutions by networking compatible hardware and software. The ultimate aim of these developments is to provide access to the intellectual resources of universities and other academic institutions for more people throughout the country through the development of a "network teaching auditorium".

Conclusion

The development of open models for teaching physics to schools in dispersed locations in Russia and Canada is based on the application of contemporary developments in information and communication technologies. In both countries educators are attempting to bring developments in the application of information and communication technologies together through the creation of educational networks. In developing these new electronic educational structures, both Russian and Canadian educators have had to consider appropriate ways of organizing teaching and learning, acknowledging both the possibilities and the limitations of the new technologies with which they are currently working.

Both Russian and Canadian educators have found that they have to be constantly aware of the issue of the compatibility of hardware and software between sites. The effectiveness of the teaching of physics to dispersed sites within networks is dependent on the extent to which hardware and software can be shared between teachers and students.

This paper describes two types of inter-networking for education purposes that have been developed during past three years in Canada and Russia. The specific parameters of each model are influenced by the geography of each country. More than 9 hours time-zone differences in Russia together with unpredictable channel capacity make asynchronous information transfer very important. Canada's location and higher performance networks makes synchronous, real-time networking a high priority.

For both models there is a common zone in a developing - knowledge base and in the creation of global experimental facilities. For both models of ODL teacher education is evolving. The next steps for integrating technology and pedagogy include:

1. Developing the architecture of an open knowledge base in physics;
2. Developing integrated Web-interfaces for knowledge resources;
3. International teacher education to maximize these developments.

Information and communication technologies are, above all, collaborative. The development of new ways of teaching and learning physics in each country has been facilitated by the convergence of information and communication technologies with growing awareness of adjustments that are needed in pedagogy to accommodate technological changes. As Russian and Canadian scientists and educators

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collaborate to improve the organization of open models for teaching to dispersed sites, it becomes increasingly possible that for teachers and students, national boundaries will disappear.

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